Digitized by the Internet Archive
in 2008 with funding from
Microsoft Corporation

http://www.archive.org/details/no8agribulle14ohiouoft niv.

VOL. XIV, NO. 8 EXTENSION BULLETIN 1918-19

LIBRARY
NOV 28 1928
UNIVERSITY OF T[illegible]

GETTING THE MOST OUT OF MANURE

by

MYRON A. BACHTELL
Department of Soils

Keeping livestock simplifies the fertility problem.

THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO
AGRICULTURAL COLLEGE EXTENSION SERVICE
CLARK S. WHEELER, *Director*
FREE—Cooperative Agricultural Extension Work—Acts of May 8 and June 30, 1914

"Manure? Why think manure? Rather think of waving wheat fields, golden corn and tempting apples."

SOME WORTH WHILE QUESTIONS WHICH ARE ANSWERED IN THIS BULLETIN

PAGE

1. What is manure? 3
2. Why is manure so effective on soils? 3
3. What determines the amount of plant food in manure? 4
4. How much plant food does a ton of fresh manure contain? 4
5. In what ways may plant food be lost from manure before it reaches the field? 5
6. Is a concrete floor a profitable investment? 6
7. How can hot fermentation be prevented? 7
8. How general should be the use of manure sheds? 8
9. What about the covered barnyard? 8
10. What is the "weak point" in manure? 9
11. How much phosphorus should be used with manure? 10
12. Does reinforced manure satisfy the requirements on livestock farms? 11
13. To what crop can manure be best applied? 12
14. Does clover derive any benefit from manure? 13
15. When should manure be applied? 14
16. Is the manure spreader a good investment? 14
17. What can be done in grain farming to take the place of manure? 15

GETTING THE MOST OUT OF MANURE

By Myron A. Bachtell

1. What is Manure?

This is a simple question but one which well can be answered seriously. How many people are there who have a true conception of the nature and value of manure? Surely those do not who regard manure merely as a necessary adjunct of livestock farming—an offensive excrement that must be moved, but which offers no potential possibilities. Neither do those who, on the other hand, regard manure as a material which possesses unusual and miraculous possibilities when used for the renewal of soil fertility and the production of crops. However, the best thinking people at the present time have a conception of manure which tends toward neither one of these undesirable and extreme views. They value manure for its worth. To them manure is a combination of plant food, organic matter, and bacteria—a product capable of being interpreted in terms of corn, potatoes, and apples as well as other food products. They recognize that in this combination of plant food, organic matter, and bacteria there is a substantial value; they recognize also that there are certain limits beyond which its value cannot be placed.

2. Why is Manure so Effective on Soils?

The effectiveness of manure may be due in part to any one of the three constituents, organic matter, bacteria, and plant food. Organic matter forms 25 percent of average manure. The beneficial effects of this constituent are most easily apparent in market gardening, where large quantities of manure are used. In general farming, where the use of manure necessarily is more limited, its value is due only in a minor measure to the organic matter which it carries. Manure also contains millions of bacteria, but in general farming, where manure is used as a part of a systematic method of soil building, their value is of secondary importance, altho in many cases they no doubt assist in promoting favorable bacterial action in the soil.

The value of manure is due largely to the plant food it contains. The elements of economic importance in manure are nitrogen, phosphorus, and potassium.[1] Anything which increases the content of these plant foods tends to increase the agricultural value of manure, while this value is diminished by processes which decrease the plant foods.

---

[1] Nitrogen, phosphorus, and potassium are terms used thruout this bulletin in preference to ammonia, phosphoric acid, and potash. It is earnestly to be desired that the time soon will come when analyses of fertilizers, etc., will be reported in terms of the elements rather than the compounds.

3. What Determines the Amount of Plant Food in Fresh Manure?

There are several factors which determine the amount of plant food in fresh manure. Most important of these is the ration fed to the animals producing the manure. During the process of digestion the various elements of plant food are assimilated into the animal body to be used in whatever quantity is demanded by the different life processes. Growing animals need these elements of plant food to build up their muscular tissues and to make a vigorous bony framework. Dairy cows must draw heavily on their feed for the nitrogen and inorganic salts that are found in milk. On the other hand, mature work animals excrete in the manure nearly as much plant food as they receive in their food.

The Ohio Experiment Station found that, of the plant food in the ration fed to fattening steers, 75 percent of the nitrogen, 78 percent of the phosphorus, and 88 percent of the potassium was recovered in the manure. Young growing animals and dairy cattle will excrete somewhat less than this proportion, while mature non-milk producing animals will excrete a greater proportion.

Manure as used, is a combination of litter and excrement. The kind of litter, as well as the amount, affects the content of plant food in each ton of manure.

4. How Much Plant Food Does a Ton of Fresh Manure Contain?

Inasmuch as manure is produced by animals of various ages and fed on different rations it is possible to give only approximately the amount of plant food in any given ton of manure. The dried manures, such as sheep and horse manures, contain more plant food per ton than do the wetter cattle and hog manures.

The data in the following table, which gives the composition of the various kinds of manure, represent the average of numerous analyses made by experiment stations.

PLANT FOOD IN MANURE
Pounds per Ton

Kind of Manure	Nitrogen	Phosphorus	Potassium
Cattle[1]	12	2.5	9
Horse[1]	14	2.	12.5
Sheep[1]	29	4.5	21
Pig[2]	10	3	6.5
Hen[3]	22	3.5	6

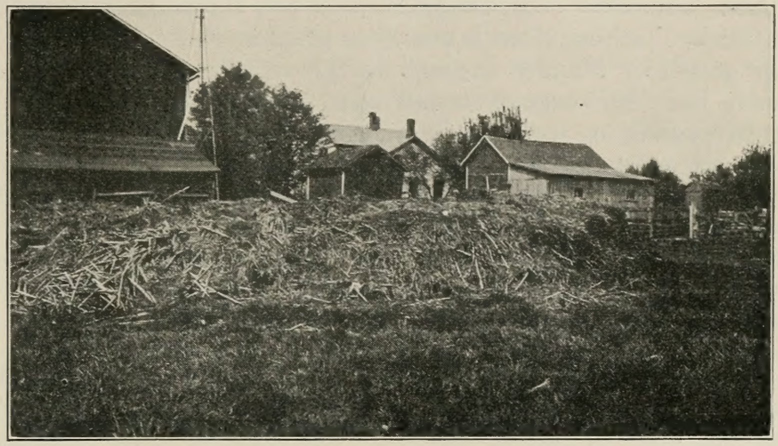
Plant food is divided between the solid and liquid manure. The liquid manure, or urine, of dairy cows contains 60 percent of the nitrogen, and 75 percent of potassium, but only a trace of the phosphorus. These figures, however, hardly give the relative value of the urine. Its value is greater than that indicated, as the plant food in urine is soluble and more readily available than in the solid manure.

---

[1] Leaflet issued by Dept. of Chemistry, Ohio Agricultural Experiment Station 1911.
[2] Van Slyke, Fertilizers and Crops.
[3] N. J. Bul. 84.

5. In What Ways May Plant Food be Lost From Manure Before it Reaches the Field?

In general there are three ways by which plant food may be lost from manure before it gets to the field. The first loss occurs when the urine is allowed to drain away. If this happens, fully 60 percent of the value of manure has been lost. The aggregate loss from this source in past times when stables were equipped with wooden floors was enormous. Even today there are stables with well made concrete floors where this loss is encouraged to continue by the arrangement of drains thru which the urine has an unobstructed flow from the stable. When it is desired to remove urine from the stable by drainage, the drains should lead to the manure pit where the liquid may be absorbed by litter of some sort.



In spite of all that has been said concerning the losses in exposed manure, this practice still is common in many sections.

The other ways by which plant food may be lost before manure reaches the field are thru hot fermentation and leaching. Hot fermentation, which is the cause of fire fanging, leads to a loss of nitrogen and organic matter. Loss thru hot fermentation is more apt to occur in dry and fibrous manures like horse manure than in the wet and compact manures such as that from cattle and hogs. In extreme cases, such as badly fire-fanged horse manure, the nitrogen is almost a total loss.

Leaching causes a loss of all plant foods found in manure. This occurs as water passes down thru the manure and seeps or flows away at the bottom of the pile. Such a loss is made possible because of the fact that manure contains water-soluble plant food. The same principle is illustrated in the making of lye by allowing water to trickle down thru ashes. The lye, as well as the dark colored water which is to be seen around manure piles, is the original water plus whatever soluble materials it has dissolved in its passage thru the ashes or manure. The ready loss of plant food from manure by leaching is indicated by the amount that is soluble in water. Tests show that approximately one-half of the nitrogen, one-half of the phosphorus and four-fifths of the potassium in manure are water soluble. The Ohio Experiment Station has shown that in practice the loss by leaching often is nearly as great as these figures indicate to be possible. Manure exposed to the weather for a period of 3 months lost 36 percent of its nitrogen, 22 percent of its phosphorus and 51 percent of its potassium. At the Cornell Experiment Station, horse manure exposed from April to September lost 62 percent of its value. At the Maryland Experiment Station a pile of manure containing 80 tons was reduced to 27 tons during exposure to the weather for 1 year. This last loss of over 66 percent was caused by hot fermentation and leaching.

6. Is a Concrete Floor a Profitable Investment?

In the past, sanitation and ease of cleaning rather than consideration of profit have dictated the building of concrete floors. The great majority of people, however, will come to think of concrete floors as a necessary part of the average barn only when they realize that they actually are a profitable investment. The Ohio Experiment Station presents data which show that concrete floors should be utilized by those men who make soil fertility investments in a businesslike way. A plank floor under 30 cows was replaced by one of concrete, and the liquid which formerly had been allowed to escape thru the cracks in the floor was drained into a cistern. Altho these cows were ordinarily well bedded, the liquid manure that was gathered in this cistern in the course of 4 months contained 155 pounds of nitrogen and 222 pounds of potassium[1]. If nitrogen is valued at 25 cents a pound and potassium 12 cents this liquid had a value of $65.39. On the basis of 7 months, which more nearly represents the time dairy cows are in the stable each year, the unabsorbed liquid would have a value of $114.43.

The Ohio Station also kept steers on concrete floors, and was able to compare the manure production with that on an ordinary well compacted earth floor. The following table gives the amount and value of plant food in the manure from a 1000-pound steer under each system.

---

[1] Thorne, Farm Manures, page 132.

VALUE OF MANURE PRODUCED BY A 1000-POUND STEER IN SIX MONTHS
Ohio Experiment[1]

	On concrete floor		On earth floor	
	Pounds	Value[2]	Pounds	Value[2]
Nitrogen	67	$16.75	54	$13.50
Phosphorus	27	3.78	24	3.36
Potassium	36	4.32	29	3.48
		$24.85		$20.34
In favor of concrete		$4.51		

The increased value of plant food in the manure from the 30 steers fed on a concrete floor for 6 months was $135.30.

If 1400 square feet is sufficient floor space for 30 animals and 10 cents per square foot is allowed for construction, a tight floor would cost $140. In the Ohio experiments the value of the plant food saved in the course of 8 or 10 months more than equalled this cost. This indicates that concrete floors are a very excellent investment. Only by having a water tight floor, such as concrete, is it possible to save all of the urine by absorption with bedding. Practical experience shows the value of concrete floors for saving hog manure. Many hog growers have said that they scarcely ever hauled manure from their hog pens before concrete floors were put in, but after having such floors several loads have been secured each year.

7. How Can Hot Fermentation be Prevented?

Hot fermentation in manure is caused by aerobic or air loving bacteria. Their disastrous effects are most noticeable in coarse and fibrous manure where air has ready entrance. Horse manure does not pack readily and is more susceptible to hot fermentation than any other manure. Cattle manure, especially that with a limited amount of bedding, does not heat readily, as it settles down into a compact heap from which the air is quite effectively excluded.

Another factor influencing hot fermentation is the water content of manure. Dry manures heat much more readily than those than contain considerable water. This fact helps to explain why it is more difficult to store horse manure than cattle manure.

The problem of preventing hot fermentation is one of excluding the air from the interior of manure piles. This is accomplished by keeping the pile moist and compact. If the liquid from the animals does not make sufficient moisture, water can be added, care being taken that the amount is not sufficient to cause leaching. If, in addition to this, animals are allowed to run over the manure and trample it into a compact mass, hot fermentation will be effectively stopped. In covered yards where manure is left for some time after the animals have been taken off, the loss from hot fermentation can be decreased by wetting the manure occasionally to prevent the top few inches from becoming unduly dry.

---

[1] Thorne, Farm Manures, page 133.
[2] Values per pounds: nitrogen 25 cts., phosphorus 14 cts., potassium 12 cts.

8. How General Should be the Use of Manure Sheds?

Every community has numerous manure piles in which manure remains exposed from a few weeks to several months, and loses from one-fifth to three-fourths of its plant food. As labor, weather and soil conditions make it impractical to haul manure every day this loss of plant food either must continue or else there must be some special measures taken to store manure. In some cases a concrete bin will solve the problem, but most men will wish to add a roof and perhaps make the floor space sufficiently large to permit driving thru the shed with their manure spreader.

At the Ohio Experiment Station a comparison of protected and exposed manure has been in progress for over 17 years. The following table gives the results that have been secured:

COMPARISON OF PROTECTED AND EXPOSED MANURE[1]
Ohio Experiment

	Yields per Acre			Value of Difference
	Corn	Wheat	Clover	
	Bus.	*Bus.*	*Lbs.*	
8 tons manure protected....	60	21	4200	......
8 tons manure exposed.....	54	20	3500	......
In favor of protected manure	6	1	700	$12.75[2]

The manure in this experiment was exposed for 3 months, during which time it decreased in agricultural value to the extent of $1.25 per ton. It would seem to be a question not of whether manure sheds are justified but, instead, whether the average farmer can afford not to have one. More manure sheds are needed on Ohio farms.

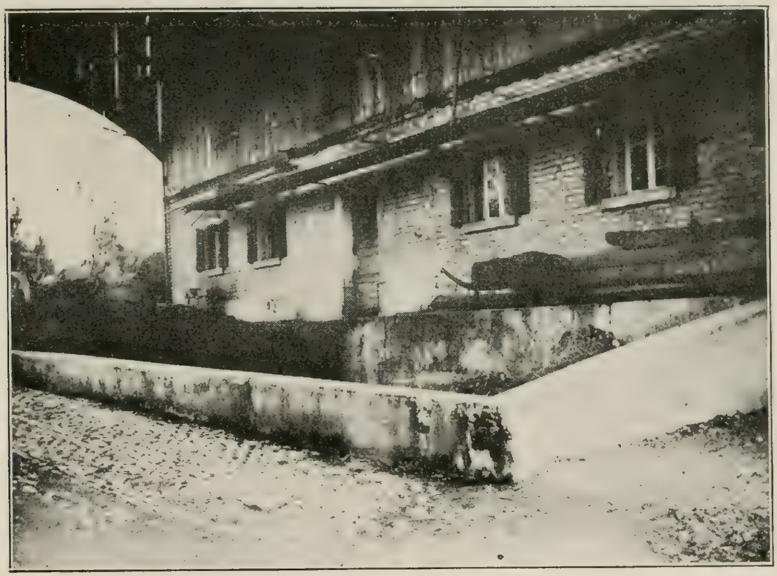
9. What About the Covered Barnyard?

The covered barnyard properly built and properly used represents a nearly ideal method for manure storage. Being larger than a manure shed it permits animals to tramp over the manure and pack it, thus reducing the loss from hot fermentation. Leaching is prevented absolutely and if a concrete floor is provided there is no chance for loss of liquid by percolation down into the soil.

---

[1] Ohio Experiment Station Circular 144.
[2] Values: Corn, $1; Wheat, $1.50; Clover $15.

Factors other than manure storage must be considered before building a covered barnyard. Dairy farmers whose products are marketed in cities should ascertain whether such a building will pass inspection. The sanitary phase must also be considered. A covered barnyard may exclude sunlight from where it is needed. Bank barns, with a bank on one side and a manure shed on the other, often are darker than desirable. In many cases this can be avoided by proper arrangement of barn and manure shed. These are not arguments against the use of covered barnyards, but rather for greater thought in their construction. Properly built, covered barnyards are sanitary, clean and conservers of plant food.



A concrete pit makes a cheap but effective means of conserving manure.

10. What is the "Weak Point" in Manure?

A few years ago it was generally thought that manure had no "weak point," but today even its most ardent advocates recognize that it has. Reference to question 4 will show that the various kinds of manure contain from three to seven times as much nitrogen and potassium as of phosphorus. This unbalanced proportion of plant food is the weak point in manure.

One need not look far to discover evidence of the effects of this unbalanced condition. Shrivelled grains of the cereals, small proportion of grain to straw, light-weight ears of corn, grain crops not properly maturing, potatoes with big vines but few tubers—all these and several others are mute evidences from the crop that the phosphorus of the soil is insufficient in proportion to the nitrogen. These evidences are often seen most easily on soils that have been heavily manured. Feeding more clover and alfalfa or buying concentrated feeds does not remedy the trouble, as these practices increase the nitrogen of manure more than the phosphorus. The remedy, however, is simple and consists in applying some commercial form of phosphorus in connection with manure.

11. How Much Phosphorus Should be Used With Manure?

There are several methods of using phosphorus with manure. The carriers of phosphorus that may be used are acid phosphate, floats, bone meal and basic slag. Of these four, floats is best used by mixing with manure before the latter is taken to the field, acid phosphate either may be mixed with manure or drilled separately, while bone meal and basic slag almost always are drilled into the soil independently of manure applications. Regardless of which method is used, the phosphorus applied is effective in supplementing the manure that has been or will be used on some crop in the rotation.

There are certain advantages to be gained by mixing floats or acid phosphate with manure. As regards floats, this method permits the use of a cheap source of phosphorus; in the case of acid phosphate there is a tendency for this material to reduce the loss of nitrogen from manure. In either case when the manure has been spread the phosphorus also has been applied with very little extra labor. When the rush of corn planting time arrives the busy farmer appreciates this point. This, perhaps, represents the principal advantage to be gained by mixing acid phosphate with manure, as it is probable that the two can be applied separately with equally good results. Each farmer will decide for himself which method to pursue. The important point is to use, at some time in the rotation, sufficient of the phosphorus carrier.

Director Thorne makes use of the term "phosphated manure." By this he means manure to each ton of which 40 pounds of acid phosphate have been added. This proportion has given most excellent results at several of the experiment farms of the state. When floats is used instead of acid phosphate this amount may be increased by one-half or even doubled. If, in addition to this, the grain crops to which manure is not applied receive from 200 to 400 pounds of acid phosphate, or its equivalent in bone meal, one may feel sure that the phosphorus supplied is sufficient to permit whatever manure is used in the rotation to produce its maximum effect.

12. Does Reinforced Manure Satisfy the Requirements on Livestock Farms?

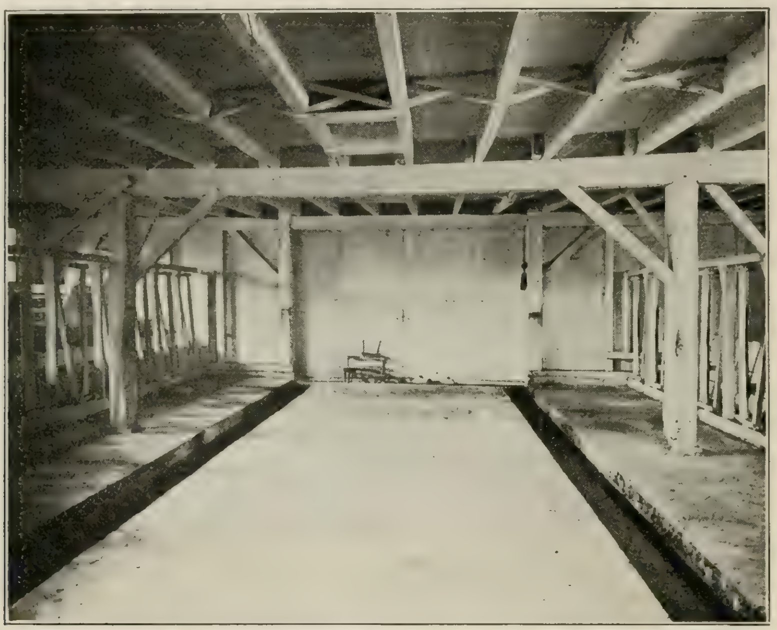
The results of experimental work and the observations of practical farmers furnish abundant evidence that manure and phosphorus are a highly satisfactory combination for the production of any crop. Men disagree, however, not only as to whether sufficient manure can be produced on the farm, but also as to whether any fertilizer is needed in addition to the manure that can be produced and the phosphorus than can be purchased. The Ohio Experiment Station has some accurate data on this matter that will answer these questions. Crops have been grown and fed to livestock and the amount of manure produced has been accurately determined. By this method it has been shown that the manure produced by feeding big crops is sufficient, when supplemented with phosphorus (and lime, where needed), to produce big crops. In one case, corn, wheat, and clover have been grown in rotation, the only treatment aside from limestone being 8 tons of manure and 320 pounds of acid phosphate per acre once each rotation. The yields from this treatment have been: corn 73 bushels, corn stover 3600 pounds, wheat 30 bushels, wheat straw 3550 pounds, and clover hay 6500 pounds[1]. If the wheat were sold and the rest of the crops made into manure on a concrete floor, the manure produced would be sufficient to cover each acre once every 3 years with 10 tons instead of 8 tons of manure. In another test the amount of manure was increased to 10 tons and the acid phosphate to 750 pounds, with the result that the following average yields have been secured, viz.: corn 77 bush-

On one farm the problem of manure conservation was solved by making use of an old shed.

---

[1] Ohio Circular 144, page 90.

els, oats 60 bushels, wheat 34 bushels, and clover 3¼ tons. Selling the wheat and feeding the remaining crops on a concrete floor would permit the production of at least 14 tons of manure, which is 1 2-5 times as much as was used in producing the crops. All yields mentioned are very excellent ones, and they have been secured on land that has only a medium amount of natural fertility. This would seem to confirm the belief that on well managed livestock farms the manure obtained by pasturing or feeding, if properly supplemented with phosphorus (and lime, where needed), will satisfy the fertility requirements. On those farms on which it has not been doing this, a study should be made of the system of making and handling manure to ascertain whether the cause of the failure is to be found in this or some other practice.



Concrete floors save all the liquid manure. They also furnish ideal conditions for the use of either acid phosphate or rock phosphate with manure.

13. To What Crop Can Manure be Best Applied?

Because of their ability to gather nitrogen from the air, legumes should not receive any great quantity of manure. Of the non-legumes, oats is not commonly manured, as the practice often causes the crop to lodge. Corn, wheat, and grass are the crops that at present receive most attention as regards manuring. Indeed, there are many farms on which a light sprinkling of manure is given each of these crops.

Applied on wheat, a light top dressing not only decreases winter killing, but also assists in getting a clover catch. Such use of manure, however, is more necessary on soils depleted of organic matter and phosphorus and on those which are acid than it is on soils whose needs for organic matter, phosphorus and limestone have been supplied by a rational and permanent system of soil building. When these needs have been met, good wheat and clover crops usually can be grown without resort to top dressing with manure.

Corn, on the other hand, is preeminently adapted to make use of large amounts of manure. It is scarcely possible to get land too rich for corn. Moreover, this crop offers an excellent opportunity for the application of manure, as the sod from the preceding hay crop is available for this purpose any time during the fall and winter. When the rotation includes a year of timothy after clover, the practice of manuring the meadow one year ahead of the corn crop is becoming very common. This greatly increases the hay crop, thus making a much better sod to turn down for corn. Many of the best farmers feel, that with this better sod plus whatever remains of the manure, the corn crop will be practically as large as tho the manure had been applied directly to it. In those sections, however, where timothy is not grown to any extent, it is probable that manure will continue quite largely to be applied to the clover sod and plowed under for corn or some other cultivated crop such as tobacco, beets, or potatoes.

14. Does Clover Derive Any Benefit from Manure?

Practical experience and experimental evidence both show that clover success is most easily obtained on well manured soils. This is true even tho the manure has been applied a year or two previous to sowing clover. The effect of manure on the yield of clover at the Ohio Experiment Station is shown in the following table:

CLOVER YIELDS AT OHIO EXPERIMENT STATION[1]

	Yield	Increase	Increase
5-year rotation[2]:	*Lbs.*	*Lbs.*	*Percent*
No manure..................	1800		
8 T. manure on grain crops...	2950	1150	64
3-year rotation[3]:			
No manure..................	3650		
4 T. manure on wheat........	4400	750	21
8 T. manure on wheat........	4950	1300	36
8 T. manure on potatoes......	4550	900	25

---

[1] Ohio Circular 144.
[2] Corn, oats, wheat, clover, timothy.
[3] Potatoes, wheat, clover.

15. When Should Manure be Applied?

It is highly desirable to have manure applied soon after it is produced. When kept under good storage conditions a delay of a week or a month is immaterial, but on many farms the manure is not well stored and the longer the delay the greater the loss of plant food. One criticism of the covered barnyard is that it induces men to become lax in the matter of prompt hauling, and spring often finds accumulations of manure several feet deep. To haul it then, takes teams and men that should be plowing. Also, it is common experience that manure applied for corn late in the spring is not as effective as it would have been had it been spread from time to time during the fall and winter.

There is no reason to fear an undue loss of plant food by hauling frequently to the field. Except on layers of ice or deep snow, manure can be hauled any day when the soil is sufficiently firm to bear a wagon or spreader. By spring all manure should be in the fields where it belongs. From the standpoint of sanitation, cleanliness and conservation of plant food it is poor policy to keep manure around the barn during the summer. Carefully removing manure from the premises once each week thru the summer does much to control the fly nuisance.

16. Is the Manure Spreader a Good Investment?

On many farms the manure spreader is a necessity as a labor saver. But in addition to being a labor saver it is an economic investment. When spreading by hand, it is difficult to get less than 16 tons of manure per acre, whereas, by machine spreading this amount can be cut down to 8 tons or less and the land covered twice as often. The Ohio Experiment Station has compared the results obtained by applying 16 tons of manure once every 5 years with those obtained by putting on during the 5 years the same amount in two applications of 8 tons each. Applied in one application, each ton has produced increased crops to the value of $2.20, but when the same amount of manure was put on in two applications the value of each ton has been increased to $2.96. By dividing the application, each ton has been increased in value by 76 cents. On the farm the only feasible way of getting this extra money out of manure is by using a manure spreader to divide the application, thus putting on less at a time, but getting over the area a greater number of times in the rotation and manuring a larger number of crops. As the amount of manure produced each year on many farms is considerably in excess of 100 tons, a manure spreader should pay for itself in a very short time. Properly cared for it will last a long time.

17. What Can be Done in Grain Farming to Take the Place of Manure?

First it may be desirable to inquire whether it is possible to grow good crops without manure. The Ohio Experiment Station has grown potatoes, wheat, and clover in rotation under two systems, one with manure, the other with commercial fertilizing materials. Under one system the only treatment has been 8 tons of manure used on potatoes. Under the other system fertilizing materials were applied on the potatoes and wheat, the amount used aggregating 400 pounds of nitrate of soda, 320 pounds of acid phosphate, and 200 pounds of muriate of potash. The results of this test are as follows:

Corn thrives on well manured land.

YIELDS SECURED FROM MANURE AND COMMERCIAL FERTILIZING MATERIALS
Ohio Experiment—19 year Average.[1]

Treatment	Yield per acre		
	Potatoes	Wheat	Clover
	Bu.	*Bu.*	*Lbs.*
8 T. manure....................	178	32	4425
400 lbs. nitrate of soda 320 lbs. acid phosphate 200 lbs. muriate of potash	177	37	4460

These results show that satisfactory crop yields can be obtained from the use of high grade commercial fertilizing materials, if these are used in sufficient amounts. If nitrate of soda is valued at $100 per ton, acid phosphate $20, and muriate of potash $100, the amounts used in the Ohio experiment would cost $33.20, or an average of $11.07 per acre per year. Altho the results have been good, the cost has been high.

---

[1] Ohio Experiment Station Circular 144.

A more practical example of what is possible without manure is found in another experiment which has been conducted by the Ohio Station. This is a comparison of grain farming and livestock farming in which corn, soybeans, wheat, and clover are the crops grown. In the livestock farming system, all crops except the wheat grain are made into manure which is returned to the soil. Under the grain system the cornstalks, soybean straw, and wheat straw, as well as the clover crop, are returned to the soil. In both systems the corn has received 2 tons of limestone and 400 pounds of acid phosphate, and the wheat 300 pounds of acid phosphate. The following table gives the yields that have been secured under the two systems of farming:

COMPARISON OF LIVESTOCK WITH GRAIN FARMING[1]
Ohio Experiment—7-year Average

System	Yield per Acre			
	Corn	Soybeans	Wheat	Clover
	Bu.	*Bu.*	*Bu.*	*Lbs.*
Livestock	65	22	32	4500
Grain	59	19	29	plowed under

Altho the livestock system leads in crop yields by a slight margin, the yields under the grain farming system are very satisfactory. Moreover, the latter yields now are larger than at the beginning of the experiment, thus indicating that the soil is increasing in fertility where the grain system is employed.

As population increases more grain must of necessity be produced for human consumption. A large part of this will be grown in a livestock system of farming, but an increasing amount probably will be produced under conditions where little or no manure is available for use. Under such conditions two alternatives present themselves. One is a large use of high grade carriers of nitrogen, phosphorus, and potassium to supply the needed plant food; the other, and probably more practical one, is to supply nitrogen and potassium by returning legumes, straw, and stover to the soil, the phosphorus needs to be met by liberal applications of some commercial carrier of this element.

---

[1] Ohio Experiment Station Bulletin 328.